4.1 Bubble Chamber CF_3I Fill Procedure

This procedure covers filling of the bubble chamber inner vessel with its nominal charge of CF_3I. Obviously there is plenty of hazards and risks here, hence this is a written procedure.

1) Review procedure "3 CF_3I Handling Procedure".

2) Ensure that the hydraulic system is filled and appropriately initialized. It should be under no pressure, with the inner vessel at a neutral bellows position, and no compressed air on the hydraulic cart.

3) Assemble the CF_3I transfer lines, vacuum pump, and transfer cart **without** connecting the CF_3I transfer bottle. The plumbing consists of a flexible connection from the CF_3I transfer bottle to a filter and the main Cartan valve (MV-22). The line is equipped with a tee to a vacuum pump down line with an isolation valve. The pump down port should be near MV-22. The cart is equipped with a 25 lb Arlyn Scale that is read out via a 4-20 ma current loop. The CF_3I transfer bottle sits on the balance.

4) Follow the "Before Handling CF_3I" section of procedure 3. Leak check the transfer line and don PPE.

5) Ensure MV-22 and the CF_3I bottle valve are closed. Open the plumbing to the vacuum pump and evacuate the CF_3I transfer lines.

6) Attach the CF_3I bottle to the plumbing and zero the Arlyn Scale.

7) Ensure that you have the "Commissioning Tool" VI operating. This software will provide access to and logging of all of the state variable data for the chamber, the CF_3I mass transfer data, the control and read-back data from the hydraulic cart and the heater/chiller unit, and photography data for the inner vessel.

8) Initiate data logging every 5 seconds.

9) Initiate cool-down[1] to just above 0°C. This will take a while. Follow procedure 2.5 "Bubble Chamber Temperature Ramp up/down" until an appropriate temperature has been achieved and stabilized. If the NESLab bath contains only water, set it to maintain a bath temperature of 2°C.

10) Compress (slightly) the chamber. Use the hydraulic piston position controls to drive the fast piston up to near its upper stop. Be very careful not to generate a pressure more than a few psi. It is only necessary to take the slack out of the

[1] The actual temperature is not critical. It needs to be cool enough to maintain the distillation relative to the ~20°C reservoir temperature.

system so that the bellows does not overextend[2] when the inner vessel is pressurized with CF_3I gas.

11) Close the valve to the isolate the vacuum pump and turn off the vacuum pump.

12) Verify that the vacuum pump line is closed, then slowly open the valve to the CF_3I tank to pressurize the lines. Approximately 80psi of pressure will fill the line.

13) Open MV-22 to initiate the distillation. Over time, one should observe the CF_3I dripping down through the water and forming a puddle in the bottom of the vessel. The mass in the tank should continuously decrease.

14) Protect the bellows from overextension by adjusting the position of the inner vessel using the hydraulic cart piston. At the end of the distillation, position the bellows near but not at full extension.

15) Allow the distillation to proceed until it slows on its own at the roughly the 2-liter mark. At this point, the water level will be just below MV-22. Close MV-22

16) Now iterate to complete the fill:
    a. Estimate the volume of CF_3I required to complete the fill.
    b. Slowly open the purge valve to the inner vessel, MV-21.
    c. Use the hydraulic piston to lift the vessel and drive out your estimated volume, up to 200 cm^3, of water.
    d. Close MV-21.
    e. Open MV-22.
    f. Use the hydraulic piston to expand the bellows to just above full extension to create a new condensation space.
    g. Allow the distillation to proceed until it slows on it's own. Close MV-22.

17) On the last iteration, cross-check the mass transfer data, the CF_3I level in the vessel, and the quantity of water removed from the vessel. Make sure you're done.

18) Isolate the CF_3I transfer bottle.

19) Open MV-22. Expand the bellows to full extension

20) Wait for the overpressure of CF_3I in the transfer line to condense. When the pressure is below 20psia, close the MV-22 and isolate the transfer line.

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[2] The bellows range, starting from its stop under vacuum, is roughly 200 cm^3. The range of the fast piston is 50 cm^3. Mainly you just need to establish that the hydraulic piston is in fact pushing up on the fast piston, and that there isn't some slack space.

21) Vent the transfer line and disconnect it from both the inner vessel and the transfer bottle. Cap the transfer bottle and the inner vessel port.

22) Ensure the "After Handling CF_3I" section of procedure 3 was followed. Wait for 5 minutes then remove respirators and barricades.

23) Ensure the cart is in a pressurized state and the pneumatic cylinder is not at its bottom stop. Then slowly charge the system with compressed air. Once you've established that the inner vessel is "floating" (i.e. that when all of the CF_3I is condensed the bellows is off its stop) you can run the pressure up to the nominal 200 psig.

24) Initiate warm up of the chamber to its operating point following procedure 2.5 "Bubble Chamber Temperature Ramp up/down".

25) Terminate data acquisition and backup the data by rsync'ing with the coupp2ls1 data disk.